Indicator: Ambient Concentrations of Ozone (004)

Ozone is a gas found in different parts of the atmosphere. Ozone in the upper atmosphere, or stratosphere, helps protect the earth from the sun's harmful rays. (The "Ozone Levels Over North America" Indicator describes trends in stratospheric ozone levels over the United States.) In the lowest level of the atmosphere, or troposphere, ozone is harmful to both human health and the environment. For this reason, ozone is often described as being "good up high and bad nearby" (Ozone: Good Up High Bad Nearby, EPA 451/K-03-001). Although some industrial sources release ozone directly into the environment, most ground-level ozone forms from chemical reactions involving nitrogen oxides (NO_x), volatile organic compounds (VOCs), and sunlight. Ozone levels are typically highest during the afternoon hours of the summer months, when the influence of direct sunlight is the greatest. (Latest Findings on National Air Quality, EPA 454/K-03-001, 2003)

Inhalation exposure to ozone has been linked to numerous respiratory health effects, including decreases in lung function, airway inflammation, and cough and pain when taking a deep a breath. Ozone exposure can aggravate lung diseases such as asthma, leading to increased medication use and increased hospital admissions and emergency room visits. Though people with respiratory problems are most vulnerable to the effects of ozone, even healthy people who are active outdoors can suffer from ozone-related health effects. Elevated concentrations of ozone can also affect vegetation and ecosystems, as the "Ozone Injury to Forest Plants" Indicator describes further. (Air Quality Criteria for Ozone and Related Photochemical Oxidants, EPA 600-P-93-004F-c, 1996).

This indicator reflects ambient concentrations in parts per million (ppm) of ground-level ozone from 1980 to 2003, based on 1-hour and 8-hour measurements. The 1-hour standard is useful in indicating potential effects during short-term "spikes" in concentrations. The longer 8-hour standard is indicative of exposures occurring over a more sustained period of time (e.g., an outdoor worker's exposure over the course of a work day). Trends for this indicator represent 299 sites that have data for the period of record in the National Air Monitoring Stations (NAMS) and State and Local Air Monitoring Stations (SLAMS) network and other special purpose monitors. Measurements are taken on both a daily and continuous basis to assess both peak concentrations and overall trends, which are derived by averaging direct measurements from these monitoring stations on a yearly basis. This indicator displays the annual fourth maximum 8-hour average and the annual second maximum 1-hour average.

What the Data Show

Figure 004-1 depicts the nationwide long-term trend in *1-hour average* ambient air concentrations of ozone. From 1980 to 2003, ozone levels decreased by 24%, based on the annual second highest daily maximum concentrations. Moreover, the 1-hour ozone levels observed in 2003 rank among the lowest levels on record, but the downward trend appears to be slowing. The map in Figure 004-2 shows how long-term trends in 1-hour average ozone levels have varied from one EPA Region to the next. All ten Regions experienced some decline in 1-hour average ozone levels during the past 25 years, except for the northwestern region (EPA Region 10), which showed no net change. The greatest reductions in 1-hour ozone concentrations were observed in the two EPA Regions (Regions 1 and 9) that had the highest ozone levels in 1980.

Figure 004-3 illustrates how *8-hour average* ambient air concentrations of ozone have changed in the United States over the last 24 years. Between 1980 and 2003, ambient ground-level ozone concentrations decreased by 18% based on the annual fourth highest daily maximum 8-hour average. Although the 8-hour ozone levels in 2003 ranked among the lowest on record, 474 counties (or parts of counties) in the United States experienced violations of the health-based ozone standard between 2000 and 2003 (EPA 2004, page 7). The map in Figure 004-4 shows how 8-hour average ozone levels have changed over the

last 24 years in each of the EPA Regions. Again, the most consistent and substantial declines in 8-hour levels were observed in Regions that originally had the highest ozone concentrations (EPA Regions 1 and 9). Most other Regions showed either less pronounced declines (EPA Regions 2 to 7) or no net change (EPA Region 8). The one exception to this trend is observed in EPA Region 10 where the annual fourth highest daily maximum 8-hour ozone levels observed in 2003 were higher than those observed in 1980. However, it is noteworthy that the ozone levels in this Region, on average, continue to be the lowest of all EPA Regions across the country.

In summary, despite reductions in ambient air concentrations of ozone and decreases in the emissions of ozone precursors over the past quarter century (see Indicators "NOx Emissions" and "VOC Emissions"), ozone remains one of the most persistent and ubiquitous air pollution issues in the U.S. In 2003, more than 100 million people live in counties with poor ozone air quality based on the national 8-hour ozone standard (EPA 2004, page 5)

Indicator Limitations

- Short-term trends in ozone concentrations are often highly dependent on meteorological conditions. This complicates efforts to interpret data for any given year, such as the increase in 8-hour average ozone levels seen in Region 10 in 2003. Air quality trends over the longer term are far less likely to be influenced by unusual meteorological conditions.
- Because most of the monitoring sites are located in urban areas, the trends might not accurately reflect conditions outside the immediate urban monitoring areas.

Data Sources

Data can be accessed in the EPA Air Quality System (AQS)
http://www.epa.gov/ttnairs1/airsaqs/index.htm

References

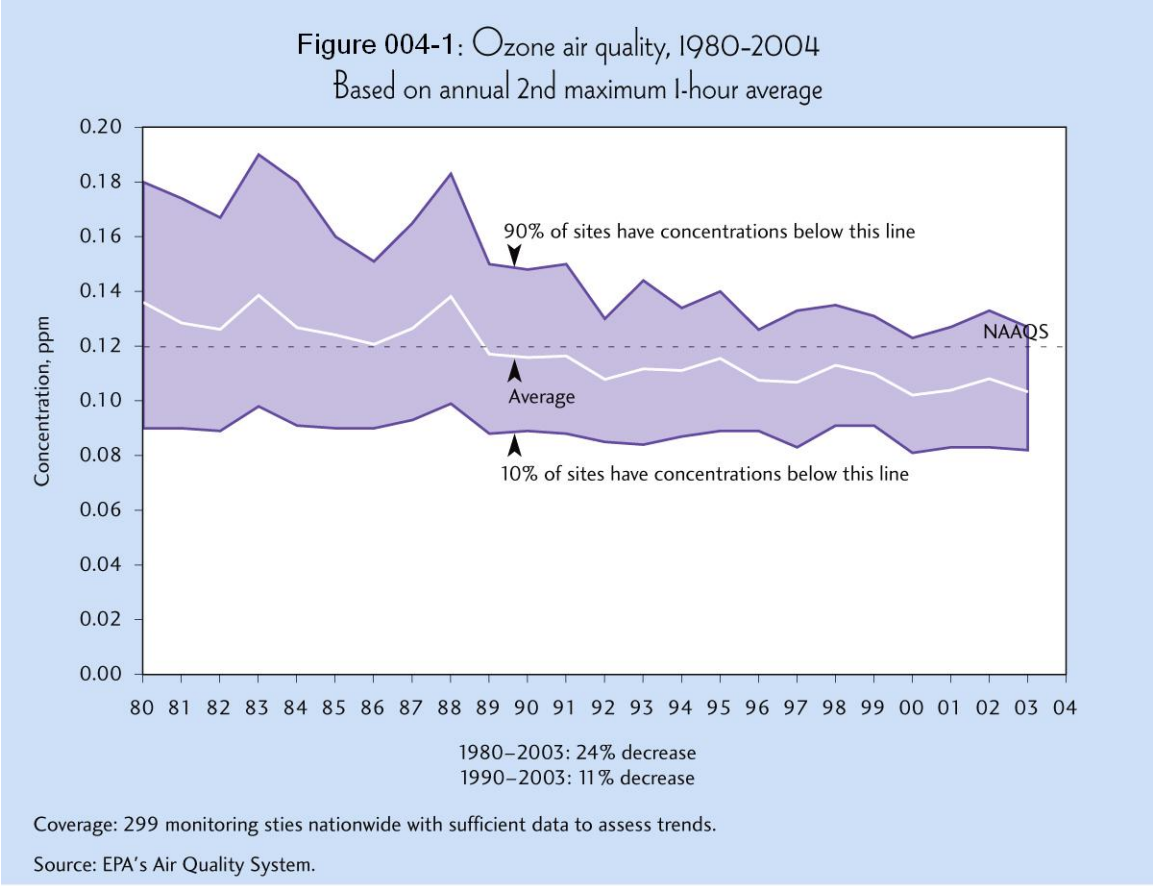
U.S. Environmental Protection Agency. Ozone: Good Up High Bad Nearby, EPA 451/K-03-001. Washington, DC; US Environmental Protection Agency, Office of Air and Radiation, June 2003.
U.S. Environmental Protection Agency.

Latest Findings on National Air Quality – 2002 Status and Trends, 2003, EPA 454/K-03-001. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, August 2003.

U.S. Environmental Protection Agency. Air Quality Criteria for Ozone and Related Photochemical Oxidants, EPA 600-P-93-004F-cF. Research Triangle Park, NC; US Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment, July 1996.

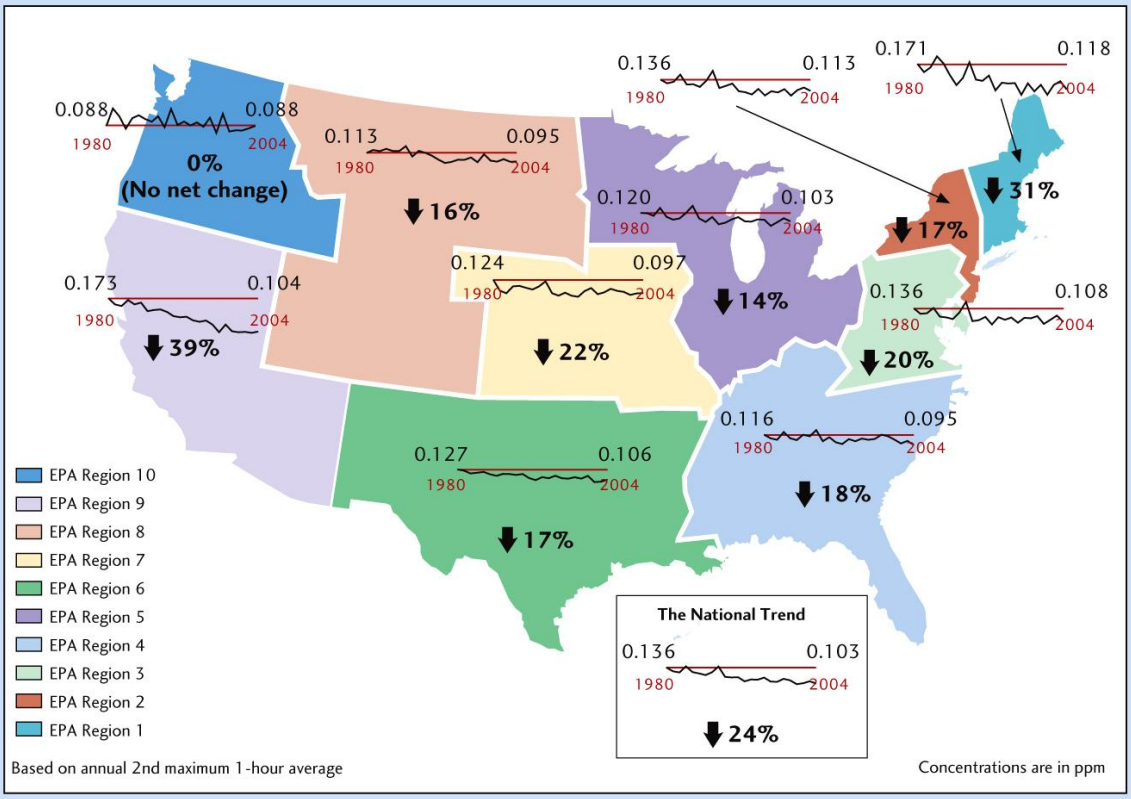
U.S. Environmental Protection Agency. The Ozone Report - Measuring Progress through 2003, EPA 454/K-04-001. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, April 2004.

Graphics



Note: Figure will be updated with 2004 data, once the data are available.

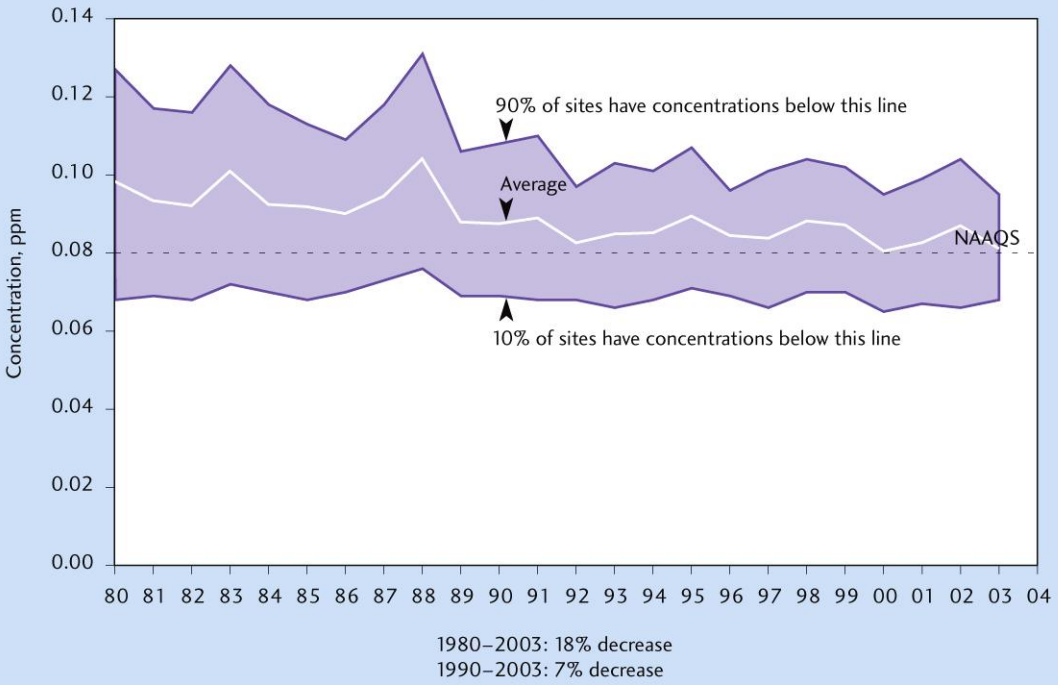
Figure 004-2 : Trends in ozone levels (1-hour), 1980-2004, averaged across EPA regions



Source: EPA's Air Quality System.

Note: Figure will be updated with 2004 data, once the data are available.

Figure 004-3: Ozone air quality, 1980-2004
Based on annual 4th maximum 8-hour average



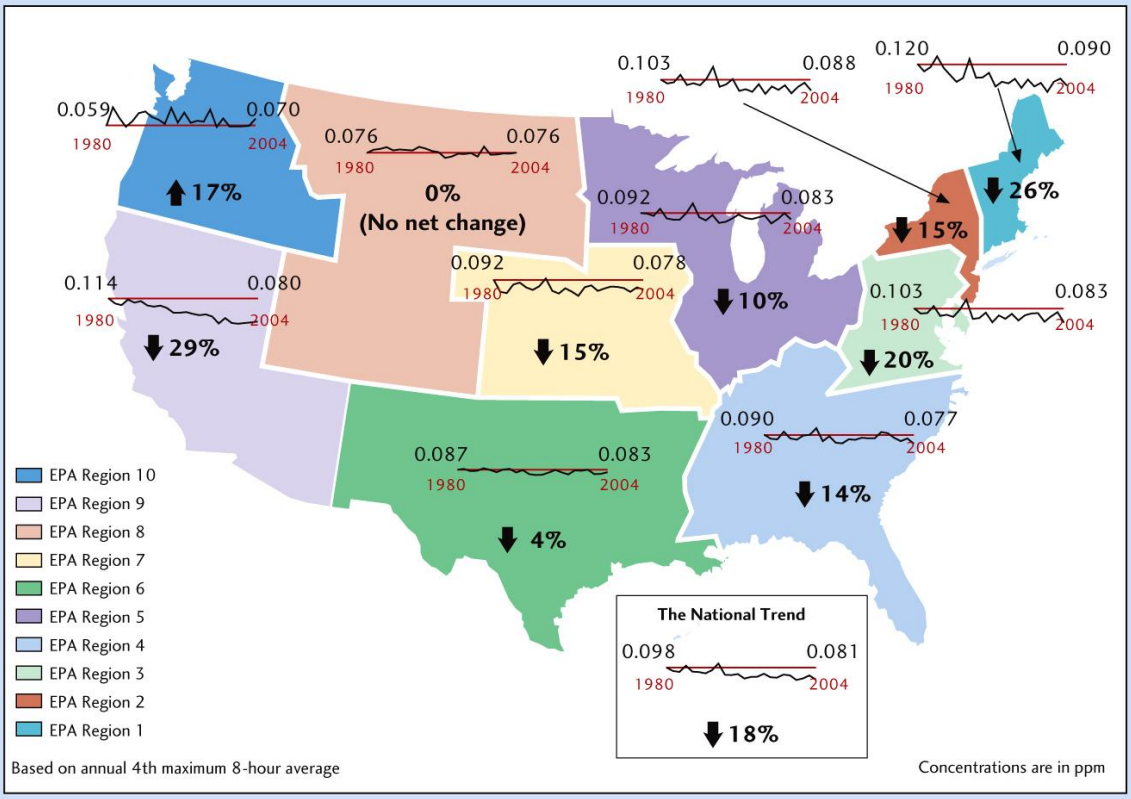
1980–2003: 18% decrease
1990–2003: 7% decrease

Coverage: 299 monitoring sties nationwide with sufficient data to assess trends.

Source: EPA's Air Quality System.

Note: Figure will be updated with 2004 data, once the data are available.

Figure 004-4: Trends in ozone levels (8-hour), 1980-2004, averaged across EPA regions



Source: EPA's Air Quality System.

Note: Figure will be updated with 2004 data, once the data are available.

R.O.E. Indicator QA/QC

Data Set Name: AMBIENT OZONE CONCENTRATIONS
Indicator Number: 004 (89073)
Data Set Source: EPA Air Quality System
Data Collection Date: 1980-2004
Data Collection Frequency: Varies. See 40 CFR Parts 53 & 58 & attached QA/QC
Data Set Description: Ambient O3 Concentrations
Primary ROE Question: What are the trends in outdoor air quality and effects on human health and ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The ambient air quality data are based on data retrieved from the Air Quality System (AQS in August 2004). These are direct measurements of pollutant concentrations at monitoring stations operated by tribes and state and local governments throughout the nation. The monitoring stations are generally located in larger urban areas. EPA and other federal agencies also operate some air quality monitoring sites on a temporary basis as a part of air pollution research studies. The national monitoring network conforms to uniform criteria for monitor siting, instrumentation, and quality assurance. The program under which the data are collected is the NAMS/SLAMS network. A description of this network includes: " 40 CFR 50 - National ambient air quality standards (NAAQS) and reference methods for determining criteria air pollutant concentrations in the atmosphere " 40 CFR 53 - Process for determining reference or equivalent methods for determining criteria air pollutant concentrations in the atmosphere " 40 CFR 58 - Ambient air quality surveillance (monitoring) requirements. Reference methods for ozone can be found at the following web site - http://www.epa.gov/ttn/amtic/files/ambient/criteria/ref405.pdf These results have been peer reviewed. The most recent review was as a part of the National Air Quality and Emissions Trends Report, 2001 EPA 454/K-02-001, September 2002. This report is available at: http://www.epa.gov/airtrends

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. In 2002, thousands of monitoring sites reported air quality data for one or more of the six National Ambient Air Quality Standards (NAAQS) pollutants to AQS. The sites consist of National Air Monitoring Stations (NAMS), State and Local Air Monitoring Stations (SLAMS), and other special-purpose monitors. NAMS were established to ensure a long-term national network for urban area-oriented ambient monitoring and to provide a systematic, consistent database for air quality comparisons and trends analysis. SLAMS allow state or local governments to develop networks tailored for their immediate monitoring needs The monitoring objectives for the NAMS/SLAMS network are found in: " 40 CFR 58, Appendix D http://www.epa.gov/ttn/amtic/ " 40 CFR 58.2(c) "

EPA 454/R-98-004, Part I, Section 3.2 http://www.epa.gov/ttn/amtic/cpreldoc.html The monitoring objectives for the NAMS/SLAMS network are found in: " 40 CFR 58, Appendix D http://www.epa.gov/ttn/amtic/ " 40 CFR 58.2(c) " EPA 454/R-98-004, Part I, Section 3.2 http://www.epa.gov/ttn/amtic/cpreldoc.html

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. The conceptual model used to derive these indicators has been used and thoroughly reviewed as part of the Agency's national report on air quality trends for 25 years. Ozone air quality monitoring sites meet the annual trends data completeness requirement if they have at least 50 percent of the daily data available for the ozone season, which varies by state, but typically runs from May through September. The model basically has three elements: 1.) Determine if year is valid for inclusion. Must have greater than or equal to 50% of required days. 2.) Determine if site is valid for trends. Must have greater than or equal to 75% of possible years in the time series. For the 24-year period 1980-2003, trend sites must have at least 18 valid years and must not be missing more than 2 consecutive years of data. 3.) Interpolate for missing years. Simple linear interpolation is used to fill in for missing years in the following way. Missing annual summary statistics for the in-between years for a site are estimated by linear interpolation from the surrounding years. Missing end points are replaced with the nearest valid year of data. The resulting data sets are statistically balanced, allowing simple statistical procedures and graphics to be easily applied. This procedure is conservative since endpoint rates of change are dampened by the interpolated estimates. References include: U.S. Environmental Protection Agency. The Ozone Report - Measuring Progress through 2003, EPA 454/K-04-001. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, April 2004. Latest Findings on National Air Quality 2002 Status and Trends, 2003, EPA 454/K-03-001. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, August 2003.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The data for these indicators are collected under a single national program of ambient air quality surveillance known as the National Air Monitoring Stations (NAMS)/State or Local Air Monitoring Stations (SLAMS) network. The NAMS/SLAMS network focus is on providing data for assessing public health consequences of criteria pollutants and, therefore, the monitors tend to be concentrated in urban areas with modest coverage in most rural areas. Pollutant specific guidance for establishing NAMS/SLAMS networks is provided in 40 CFR 58, Appendix D.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The network is not focused on sensitive populations like children, the elderly, asthmatics, etc., but samples them proportion to their occurrence in the general populations of the areas monitored.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Yes, annual values are established which represent the levels of the corresponding national ambient air quality standard (NAAQS), and are 0.125 ppm for 1-hour ozone and 0.085 ppm for 8-hour ozone. These levels are indicative of the state of the environment with respect to ambient air concentrations of ozone.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Standard data documentation is available to support these data and can be accessed at: General Air Quality and National Monitoring Network - http://www.epa.gov/ttn/amtic/moninfo.html National Air Quality and Emissions Trends Report, 2003 Special Studies Edition - http://www.epa.gov/air/airtrends/aqtrnd03/

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Yes. The data used to develop these indicators are available through the Air Quality Subsystem of the Aerometric Information Retrieval System (AIRS). Information on AIRS can be obtained at: http://www.epa.gov/ttn/airs/. In addition, data from AIRS can be accessed via the Internet at: http://www.epa.gov/air/data/index.html

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. The Ambient Monitoring Technology Information Center (AMTIC) contains information and files on ambient air quality monitoring programs, details on monitoring methods, relevant documents and articles, information on air quality trends and nonattainment areas, and federal regulations related to ambient air quality monitoring. This information can be found at http://www.epa.gov/ttn/amtic/ .

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The QA/QC of the national air monitoring program has several major components: the Data Quality Objective (DQO) process, reference and equivalent methods program, EPA s National Performance Audit Program (NPAP), system audits, and network reviews (Available on the Internet: www.epa.gov/ttn/amtic/npaplist.html) To ensure quality data, the SLAMS are required to meet the following: 1) each site must meet network design and site criteria; 2) each site must provide adequate QA assessment, control, and corrective action functions according to minimum program requirements; 3) all sampling methods and equipment must meet EPA reference or equivalent requirements; 4)

acceptable data validation and record keeping procedures must be followed; and 5) data from SLAMS must be summarized and reported annually to EPA. Finally, there are system audits that regularly review the overall air quality data collection activity for any needed changes or corrections. Further information available on the Internet: http://www.epa.gov/cludygxb/programs/namslam.html and through United States EPA's Quality Assurance Handbook (EPA-454/R-98-004 Section 15) There is a Quality Assurance Project Plan from each state or local agency operating a NAMS/SLAMS monitor meeting the AEPA Requirements for Quality Assurance Project Plans@, EPA QA/R-5. The quality assurance plans for specific sites are publicly available by request to the reporting agency or the corresponding EPA Regional Office. The plans are audited at least once every three years as required in 40 CFR 58, Appendix A, Section 2.5. In addition, the data repository itself (i.e. AQS) provides direct access to two of the more prominent quality assurance indicators (i.e., precision and accuracy).

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes. The air quality statistics presented relate to the pollutant specific NAAQS and comply with the recommendations of the Intra-Agency Task Force on Air Quality Indicators. A composite average of each trend statistic is used in the graphical presentations. All sites were weighted equally in calculating the composite average trend statistic. Missing annual summary statistics for the second through ninth years for a site are estimated by linear interpolation from the surrounding years. Missing end points are replaced with the nearest valid year of data. The resulting data sets are statistically balanced, allowing simple statistical procedures and graphics to be easily applied. This procedure is conservative since endpoint rates of change are dampened by the interpolated estimates.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes. The data repository itself (i.e. AQS) provides direct access to two of the more prominent quality assurance indicators (i.e., precision and accuracy).

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

We are not aware of any sources of error that may affect the findings developed from these data.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The national air monitoring network for the six criteria air pollutants is extensive; however, there are far more monitors in urban areas than in rural areas. Monitoring in

urban areas helps to characterize population exposures, because population tends to be concentrated in urban areas. More rural monitoring might help scientists assess transport and ecological effects, although EPA uses additional tools and techniques (e.g., models and spatial analyses) to augment limited monitoring in some areas and to better characterize pressures on ecological condition. EPA is currently conducting a national assessment of the existing ambient monitoring networks and is analyzing, among other issues, the need for and appropriateness of each of the nation s urban monitors.